



4ª ed

MIM

Athletes' medical exams: electronic Periodic Health Evaluation management system

Emanuel dos Anjos Santos Silva

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INFORMÁTICA MÉDICA
2º CICLO DE ESTUDOS

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Abstract

Keywords: Periodic Health Evaluation, Pre-participation physical Evaluation, Remote ECG interpretation, Sports Medicine Exams.

Introduction: Sports participation is important from a public health perspective and the Pre-Participation physical Evaluation, performed annually is aimed for all sporting population. The screening programme includes an Electrocardiogram (ECG) and a medical assessment of Personal and Family history. In Portugal, as published in *Diário da República*, it's necessary to conduct an evaluation as in the paper form *Exame Médico Desportivo(EMD)* and, at the moment, the workflow has some problems such as athlete's misleading information and difficulties retrieving previous data for clinical evaluation. Internet seems to represent the ideal platform to improve clinical practice related to sports medicine evaluations.

Aims: The main objectives of this study are: to Design, to Implement and to Evaluate an electronic management system of *Exames de Aptidão Médico Desportivos(EAMD)*.

Methods: A Web Application (*eamd.org*) was developed to gather information from several system actors allowing sports medicine specialist to conduct an electronic version of EMD questionnaire. The application enables remote ECG interpretation by a cardiologist. Differences between electronic and paper versions were compared and healthcare system actors were interviewed for a qualitative overview of the system. System Usability Scale (SUS) questionnaire were given to these same actors to evaluate user satisfaction.

Results: Healthcare system actors can perform their tasks using the application, including the ECG remote interpretation. Differences were found in the two compared versions due to the obligation of answers in the electronic version. Sixty three percent (63%) of the athletes declared that they were

subjected to sports medicine medical evaluation at least once in the past. SUS questionnaire resulted in mean score of 84.

Discussion: This prototype had a positive feedback from healthcare providers involved in the project and allowed them to accomplish their tasks. Sports medicine physician needs to have fields open of validation in the electronic version, to continue efficiently because some points may not need an answer (e.g. number of weekly trainings). The percentage of athletes declaring that have already done an EAMD seems to validate the need for clinical history review expressed by the sports medicine specialist. For medical history confirmation purposes, the application should be used at another level (e.g. national). The development of this prototype intends to be one more step in collecting facts for future work.

Súmario

Palavras-chave: Avaliação Periódica de Saúde, avaliação médica de pré-participação desportiva, interpretação remota de ECG, Exames de Medicina Desportiva.

Introdução: A prática de desporto é importante do ponto de vista de saúde pública e uma avaliação médica anterior à sua prática deverá ser realizada anualmente por toda a população desportiva. O exame médico inclui um eletrocardiograma (ECG) e a apreciação do historial clínico pessoal e familiar. Em Portugal é necessário realizar a avaliação médica segundo o formulário em papel do Exame Médico Desportivo, publicado no Diário da República. Esta metodologia traz alguns problemas tais como as informações imprecisas dos atletas e a falta de acesso rápido à informação clínica anterior para uma melhor avaliação. A Internet poderá ser a plataforma ideal no propósito de melhorar a prática clínica relacionada com as avaliações de medicina desportiva.

Objetivos: Os principais objetivos deste estudo são: o Desenho, a Implementação e a Avaliação de um sistema eletrónico para a gestão dos Exames de Aptidão Médico Desportivos (EAMD).

Métodos: Foi desenvolvida uma aplicação Web que reúne informações provenientes de vários utilizadores do sistema, permitindo ao especialista em medicina desportiva realizar uma versão eletrónica do questionário *Exame Médico Desportivo*. Foi criada na aplicação uma forma de interpretação remota de ECGs pelo cardiologista. Foram comparadas as diferenças entre as versões eletrónicas e em papel. No sentido de obter uma avaliação qualitativa foram entrevistados os prestadores de cuidados de saúde, utilizadores do sistema. O questionário *System Usability Scale(SUS)* foi também entregue a estes mesmos utilizadores para avaliar a satisfação na sua utilização.

Resultados: Os prestadores de cuidados de saúde, utilizadores do sistema, ao utilizar a aplicação podem executar as suas tarefas, incluindo a interpretação remota de ECGs. Foram encontradas diferenças entre os dois formatos em

estudo devido à obrigatoriedade de respostas na versão electrónica. Sessenta e três por cento (63%) dos atletas no estudo declararam ter já realizado pelo menos um Exame Médico Desportivo anteriormente. O questionário SUS obteve a pontuação média de 84 (SUS Score), revelando satisfação na utilização do sistema.

Discussão: Este protótipo obteve um feedback positivo dos profissionais de saúde envolvidos no projeto e permitiu a realização das suas tarefas.

O médico de medicina desportiva precisa de ter campos abertos de validação de forma a poder continuar o questionário electrónico, já que alguns pontos podem não necessitar de resposta (por exemplo, o número de treinos semanais). A percentagem de atletas que declararam ter já efectuado um EAMD parece justificar a necessidade de validação do historial clínico expressa pelo especialista em medicina desportiva, mas para efeitos de confirmação desse mesmo historial médico, a aplicação deve ser usado a outro nível (por exemplo, nacional). O desenvolvimento deste protótipo pretende ser mais um passo na recolha de dados para trabalhos futuros.

Preamble

Working in a Healthcare institution, observing Sports Medicine exams workflow and dialoguing with sports medicine involved personnel, it was clear to me that this area could be more efficient providing healthcare services if better supported and organized.

After doing a previous review in the subject, analyzing the workflow of a sports medicine evaluation exam and what it represents - an assessment of the athlete's current health status and frequently the entry point for medical care - information technologies benefits can be applied to this medical field. Thus, I've concluded that this could be one of the areas, within several, with clear potential to combine medicine and information technologies to optimize the doctor-patient relationship.

This project made me realize the difficulties of implementing a clinical record digital version in several aspects, such as the disruption of professional's workflow and care provision.

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Acronyms

AAFP - American Academy of Family Physicians	
AAP - American Academy of Pediatrics	
ACSM - American College of Sports Medicine	
ACSS- Administração Central do Sistema de Saúde	
AHA - American Heart Association	
AMSSM - American Medical Society for Sports Medicine	
ASR - Automated System Recovery	
(e-)EAMD –(electronic-) Exame de Aptidão Médico Desportivo	
ECG - Electrocardiogram	
ESC- European Society of Cardiology	
FERPA - Family Education Rights and Privacy Act	
FIFA- Fédération Internationale de Football Association	
HIPAA - Health Insurance Portability and Accountability Act	
HTML - Hypertext Markup Language	
IAAF- International Amateur Athletic Federation	
IHF- International Handball Federation	
INSEP - Institut National du Sport et Education Physique	
IOC - International Olympic Committee	
IT - Information Technology	
NCAA - National Collegiate Athletic Association	
PDF – Portable Document Format	
PHE – Periodic Health Evaluation	
PHP - PHP: Hypertext Preprocessor	
PPE – Preparticipation Physical Evaluation	
SQL –Structured Query Language	
SSL - Secure Sockets Layer	
UNESCO - United Nations Educational, Scientific and Cultural Organization	
URL - Uniform Resource Locator	

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Thesis Organization

This thesis is divided into eight chapters: Introduction, Objectives, Background, System Design, System Implementation, System Evaluation, Conclusion and References.

Introduction chapter presents Sports medicine specialty, the Periodic Health Evaluation and its relation to sports medicine. The study of the Portuguese scenario, its complexity and what led to the choice of this issue is exemplified here. Information technologies and telehealth advantages are showed in this chapter.

Objective chapter enumerates the main objectives for this study: to design, to implement and to evaluate the electronic EAMD management system.

Background chapter describes the findings in the literature review made on the thesis subject and how sports medicine examinations are perceived in other countries.

System Design chapter describes Legal, Ethical and Medical aspects researched for the implementation of this prototype. This chapter describes technical decisions and security implementations observed as well as perceived limitations.

System Implementation chapter provides a concise description by roles of developed functionalities, aided by application screen illustrations.

System Evaluation chapter describes the methodology used for evaluating the application, the outcomes, the outlook of healthcare institution system actors and what can be done to improve it.

Conclusion chapter confronts the work completed with the results obtained launching possible directions for future work and what have to be done to improve e-EAMD management system.

References chapter provides the references used in this project and resulting document.

1. Introduction

It is written in the International Charter Of Physical Education And Sport in article 1.1 of the United Nations Educational, Scientific and Cultural Organization (UNESCO) that: “the practice of physical education and sport is a fundamental right for all” and “Every human being has a fundamental right of access to physical education and sport, which are essential for the full development of his personality.” Article 6.1 makes clear that “Research and evaluation in physical education and sport should make for the progress of all forms of sport and help to bring about an improvement in the health and safety of participants as well as in training methods and organization and management procedures”(UNESCO, 1978).

Sports participation is important from a public health perspective. There is no longer doubt that regular physical activity reduces the risk of premature mortality in general and of heart illnesses. (Ljungqvist et al., 2009).

1.1. Sports medicine

Sports medicine is a multidisciplinary clinical and academic medical specialty (Pigozzi, 2009) and can be defined as in Oxford Dictionary of Sports & Medicine: A branch of medicine concerned with the welfare of athletes, and deals with the science and medical treatment of those involved in sports and physical activities. The objectives of sports medicine include evaluation of health status, the protection, and treatment of injuries, and the preparation of an individual for physical activity in its full range of intensity.” Sports medicine is an important element of what is generally referred to as public health; it aims to improve the health of the populations. In addition, sports medicine involves all people engaged in physical activities, from recreational to professional participation in sports. As participation in physical activities increased, sports

medicine specialists from several countries set the necessary elements of a periodic healthcare evaluation for athletes (Pigozzi, 2009).

In summary, sports medicine is a clinical specialty at work for a specific population (Pigozzi, 2009).

In the European Union, 12 countries accredit sports medicine as a clinical specialty programme (Bulgaria, Czech Republic, Finland, Holland, Ireland, Italy, Latvia, Portugal, Romania, Slovenia, Spain and UK) (Pigozzi, 2009).

1.2. Periodic Health Evaluation

Pre-Participation physical Examination (PPE) frequently is the athlete's Periodic Health Evaluation (PHE) since is conducted at least once a year, prior to season sports events and is a vital step for safe participation in organized sports. PPE may be the only contact that many athletes will have with physicians and should be seen as an opportunity for education concerning health risks and health-related behavior. The key purpose of the PPE is to detect injuries or medical conditions that may place a competitor at risk for safe participation. Athletes might be affected by silent disorders that do not have evident symptoms and only perceived in periodic health evaluations. One example is cardiovascular abnormalities, such as hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy or congenital coronary arteries (Ingersoll, 2009).

The value of PHE is well recognized and since 2007, International Olympic Committee (IOC) is developing various programs aiming the prevention of injuries and diseases in high competition sports. This development is happening with the collaboration of other entities such as Fédération Internationale de Football Association (FIFA), Internationale Handball Federation (IHF) and International Amateur Athletic Federation (IAAF).

The Olympic Games is by far the largest sports event in the world and IOC has annual education meetings for team physicians and a major conference every third year where researchers from around the world could meet to discuss challenges and results in the field of prevention of injuries and diseases (Ljungqvist et al., 2009). Through these initiatives IOC is continuously stressing the need of protection of the athlete health (Engebretsen, 2009).

Despite the efforts made by top sports federations in the academic training of healthcare professionals, general population seems alienated from this necessity. An interesting discovery in the literature search was the value given by North American student-Athletes to PPE.

A majority of athletes (66%) believed they could safely participate in athletics and avoid severe injuries or death and minor injuries without undergoing a PPE. Most athletes believed the PPE prevents or helps to prevent both major (89%) and minor (76%) injuries. Male and female respondents would not be uncomfortable with a physician or other health care provider asking questions regarding health-related issues. However, many athletes (especially women) believed that the PPE is not a place for specific questions (questions related to sexual activity and health, eating disorders, smoking, and personal and family use of alcohol) (Carek & Futrell, 1999).

1.3. Portuguese Scenario

In Portugal, the PPE is the *Exame Médico Desportivo*, renewed in the athlete's birth month (mentioned in the Portuguese Legislation: *Despacho* n.º 25 357/2006, *de 28 de Novembro de 2006*).

Until 1988, the *Exame Médico Desportivo* (EMD) was performed in sports medicine centers (*Centros de Medicina Desportiva*) that existed in all the district capitals. Since 1988, any doctor can perform EAMD exams if he feels entitled to do so (Consensus among colleges in the specialty of Sports Medicine and Family Medicine), with the exception of high performance athletes that still needs to make the medical evaluation in *Centros de Medicina Desportiva*.

In addition to high performance athletes, teams and sports in general, medical examination is aimed for all of the sporting population and must be performed annually. EMD should be performed in a healthcare institution, having the athlete after admission to perform an ECG and all EMD items assessed (ideally) by a sports medicine specialist as recommended by several authors/institutions (ACSM, 2011; Ramos, 2010).

Exame Médico Desportivo includes:

- Medical evaluation of health status;
- Rest ECG;
- Treadmill effort analysis (when over 35 years);

- Certificate of clearance;
- Examination paper form as published in *Diário da República* (figure 1).

Presidência do Conselho de Ministros
Secretaria de Estado da Juventude e do Desporto
Instituto do Desporto de Portugal

EXAME MÉDICO DESPORTIVO

Exame N.º: _____ DATA: ____/____/____

Nome: _____ Sobrenome: _____

Data de Nascimento: ____/____/____ Nacionalidade: _____

Morada: _____ Localidade: _____

C. Postal: _____ Localidade: _____

Clube: _____ Modalidade: _____

Nome do Médico: _____

N.º: _____ - C. _____

COLAR VINCULADO MÉDICO _____

CARIMBO DA INSTITUIÇÃO PÚBLICA DE MEDICINA DESPORTIVA _____

DECISÃO MÉDICA _____

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Figure 1 - Form “Exame Médico Desportivo”

Problems observed in this methodology are:

- Bureaucracy;
- Athletes misleading information and subsequent confirmation (effectiveness of history and physical examination);
- Difficulties retrieving data for previous clinical evaluation;

When justified, EAMD exams can be performed with an expensive, heavy administrative processes and time consuming visit to a sports institution by a medical team comprising a cardiologist, a sports medicine specialist and a cardiology technician. Or in alternative, a four step exam as in Table 1.

Table 1: Four Step EMD

Step	Location	Responsibility	Process
1	Sports Institution	Cardiology technician	Performs all athletes electrocardiograms
2	Sports Institution	Sports medicine specialist	Evaluates athletes health conditions
3	Healthcare Institution	Cardiologist	Evaluates the ECG's
4	Healthcare Institution	Sports medicine specialist	Evaluates EAMD after ECG review

Having these steps, in a sports institution visit or even in a healthcare institution, the bureaucracy involved, the clinical storage and retrieval difficulties makes it a costly exam. If travelling costs are accounted for a significant amount of the total cost of healthcare, patients and providers identify that electronic communications have the potential to improve care by reducing costs (Brennan & Starren, 2006).

1.4. Information Technologies and sports medicine

After a previous review of the subject and analyzing the workflow of an EAMD process, IT benefits seemed obvious. A solution to previously mentioned problems can be obtained introducing information technologies(IT) and centralizing information, improving “today’s system efficiency” if a well-designed system is implemented. Information technology is an important tool widely used for acquisition, processing, storage and dissemination of all kinds of digital information by combining computing and telecommunications (Xilong & Yuhang, 2012). The employment of a healthcare information system can reduce costs and improve service quality and productivity (Vogel & Perreault, 2006) but to fit into “every day practice” of clinicians, technology must optimize three major components of a clinician’s time: time spent with patients, time spent on documentation, and time spent on continuous learning

(Wang C, 2012). Technology has been contributing to Sports Medicine from diagnostics, management, prevention, and performance enhancement (Tan, 2008). IT may be a way to optimize the doctor-patient relationship either by the introduction of telehealth (remote ECG interpretation) as well as endowing athletes and physicians of a complete medical record for sports related subjects, allowing these two actors the same level of information.

1.5. Telehealth

A definition widely accepted of telehealth is that it involves the use of modern information technology to deliver health services to remote patients and to facilitate information exchange between primary care physicians and specialists distant from each other (Bashshur et al., 1997). Telehealth systems might be categorized into synchronous (real-time) or asynchronous (store-and-forward). Remote interpretation is a category of store-and-forward telehealth that involves the capture of data at one site and transmission to other site for interpretation (Brennan & Starren, 2006). Remote interpretation of ECGs has been used by cardiologists mainly in the form of sound signals transmission or by faxing ECGs print-outs (Lieberman, 2008) (Ong, Chia, Ng, & Choo, 1995). Remote interpretation gains importance as increased communications bandwidths with reduced costs spreads geographically. Additionally, cardiologists seems to make the same diagnoses when viewing monitor-displayed ECGs as they do when viewing paper-displayed ECGs (Pettis et al., 1999).

2. Objectives

The main objectives of this study are: to design, to implement and to evaluate an electronic EAMD management system (eamd.org), that allows the following:

- ✓ Ensure that an athlete is fit for physical activities;
- ✓ Endow the athlete of a complete medical record for sports related purposes;
- ✓ Provide physicians a way to access the medical history and treatments when needed;
- ✓ The possibility of having an ECG seen by a cardiologist anywhere;
- ✓ Assist confirming that is being met what is described in legislation;
- ✓ Easily verify the validity of an EAMD;
- ✓ Possibility of connection to current billing/appointment system.

Athletes, users of the system, should be able to consult personal information and data related to health evaluations.

Teams and sports federations present in the eamd.org system should be able to easily verify that an athlete as a valid EAMD and is fit for physical activities, as required by legislation.

As the system is online, appointments should be better managed, improving interaction with teams, sports federations, athletes and healthcare institutions administrative staff.

The sports medicine specialists should have always access to a given athlete EAMD and easily verify the effectiveness of medical history and physical examination.

ECGs should be interpreted by a cardiologist remotely and later viewed and printed by any other clinician with that particular need.

3. Background

In order to compete at top levels, athletes have to both protect and risk their health at the same time. Young athletes have the additional task of handling with significant physical, psychological and social alterations. The contradiction of protecting and risking adolescent athletes health in sports events needs developments in health promotion and protection strategies (Thiel et al., 2011). Athletes were monitored during the Athens Olympic Games, and an injury surveillance system was applied for all team sports. Throughout the Beijing Games, IOC ran an injury surveillance system that included all athletes, and reported a 10% incidence of injuries. With near 11000 athletes expected from more than 200 countries, the XXX London 2012 Olympic Games will be one of the largest sports events ever and in London the surveillance system will include disease conditions as well (Steffen, Soligard, & Engebretsen, 2012). Surveillance studies are fundamental in providing evidence for healthcare development in sports as well as for evolving prevention programs (Ljungqvist et al., 2009). These systems require a real-time information system.

According to International Olympic Committee (Ingersoll, 2009), in the context of designing and implementing athletes PHE, the following considerations needs to be taken into account:

- PHE should be based on sound scientific and medical criteria;
- PHE should be performed in the primary interest of the athlete, that is, assessing his/her health in relation to his/her practice of a given sport;
- PHE should be performed under the responsibility of a physician trained in sports medicine, preferably by the physician responsible for providing ongoing medical care for the athlete, e.g. the team physician;
- The decision concerning the nature and scope of the PHE should take into account individual factors, such as the geographical region, the sport discipline, the level of competition, age and gender of the athlete;
- The setting of the evaluation should be chosen to optimize the accuracy of the examination and respect the privacy of the athlete. The PHE

should preferably be carried out in the physician's office, which assures privacy, access to prior medical records, and an appropriate patient-physician relationship;

- A physician can only perform a PHE with the free and informed consent of the athlete and, if applicable, his/her legal guardian;
- If PHE evidences that an athlete is at serious medical risk, the physician must strongly discourage the athlete from continuing training or competing until the necessary medical measures have been taken. Based on such advice, it is the responsibility of the athlete to decide whether to continue training or competing;
- If a physician is requested to issue a medical certificate, he or she must have explained in advance to the athlete the reason for the PHE and its outcome, as well as the nature of information provided to the third parties. In principle, the medical certificate may only indicate the athlete's fitness or unfitness to participate in training or competition and should minimize disclosure of confidential medical information.

3.1 Motivation for including the 12-lead ECG

An electrocardiogram is a digital record of effective action potentials of heart muscle fibers and for that reason it contains important information about the heart function (Augustyniak, 2004).

Regular participation in training and sports competitions are associated with an increased risk for sudden cardiac death, with an average relative risk for athletes of 2.8 times compared with non-athletic counterpart. It's recognized, though, that sport itself is not the cause for higher incidence of sudden cardiac death. It is the mixture of demanding physical exercise in athletes with underlying cardiac diseases that can trigger threatening arrhythmias leading to cardiac arrest. In adult athletes (over 35 years) exercise ECG testing in the context of PPE is effective to detect unsuspected cardiac abnormalities and is currently recommended for athletes with cardiovascular risk profile (Ingersoll, 2009). European and North American cardiologists are debating the need for mandatory electrocardiogram screening of athletes in order to prevent sudden cardiac death. European investigators have presented new evidence to support the need of ECG screening. A decline in sudden cardiac deaths among Italian athletes is noted after the introduction of mandatory ECG screening in Italy (Corrado et al., 2006; Shephard, 2011). Although the recommendations of the European Society of Cardiology (ESC) and the IOC that ECG screening

should be included in the pre-participation screening process, the American Heart Association (AHA) has recently reaffirmed its position on pre-participation screening for cardiovascular abnormalities in competitive athletes. AHA suggests that ECG screening is not warranted as a component of pre-participation evaluations except if specific observations in the history or physical examination exists causing a more extensive cardiovascular evaluation (Corrado et al., 2006).

Italian data suggest that cardiovascular screening programs might save lives, but few countries have fully adopted such practices and is defended that international consensus should be achieved on who should perform an ECG in pre-participation screening, who should perform the screening, what tests the screening should consist of, and what criteria should be used to restrict participation (Douglas, 2008).

3.2 Pre-participation screenings programmes

Italy has legally instructed the screening process. Under a law passed in 1971 and revised later in 1982, Italian athletes participating in organized competitive sports must go through physical examination, a 12-lead ECG, and a 3-minute exercise step test. The Italian screening is performed by sports medicine physicians who have undergone an additional 4 years of graduate training in sports medicine and sports cardiology. The professionalism of this screening process is in marked contrast with system like the American, in which such examinations have in the past been performed by other providers (Thompson, 2009). Pre-participation screening evaluations are usually performed in sports clinics and private offices that are present in almost all communities with a population of more than 10000 people. An estimated population of over 3 million competitive athletes is evaluated annually throughout Italy within this pre-participation screening programme to exclude cardiovascular diseases (Pelliccia et al., 2006).

In United Kingdom, in the case of professional team sports, there are no legal requirements for pre-season medical assessment of players. Deaths of several elite athletes from sudden cardiac arrest have focused the attention of sports regulators in the management of sports related health risks. Guidance on pre-participation evaluation for athletes in the United Kingdom is limited,

although the national regulators of football and rugby leagues supports cardiovascular and musculoskeletal screening for youth players, and rugby union has a concussion management programme for elite players in pre-season and post-injury assessments (Fuller, Ojelade, & Taylor, 2007). United Kingdom now debates if sports medicine should not play a role in the National Health Service. Sport and Exercise Medicine was granted specialty status in the UK in 2005. Public health issues, such as increasing obesity problems and the need for specialist advice in sports injuries have increased the necessity for these services. However, there is an apparent lack of a consensus on the role of Sport and Exercise Medicine physicians in the National Health Service or how these services should be delivered (O'Halloran et al., 2009).

In France, the present law dated from June 2006, which is included in the Public Health Code, imposes medical examinations prior to registering on the list of top athletes. The exams must be done by a sports medicine specialist and include a rest electrocardiogram (Joussellin, 2006).

3.3 electronic Pre-Participation physical Evaluation

In the literature and Internet research made, the only examples found of an electronic based version of PPE were in the United States. In the United States, qualifications for the health care professionals who perform the PPE are based on practitioner availability, clinical expertise and individual state laws (ACSM, 2011). National Collegiate Athletic Association (NCAA) imposes the PPE prior to participation, and some schools use Web based forms that an athlete fills out on their own and sends back before sports practice. Most use some variation of the PPE paper form version (Figure 2) as recommended by the American College of Cardiology and the Pre-participation Physical Evaluation book (AAFP, ACSM, AMSSM, & AAP, 2010).

PREPARTICIPATION PHYSICAL EVALUATION HISTORY FORM
(Note: This form is to be filled out by the patient and parent prior to seeing the physician. The physician should keep this form in the chart.)

Date of Exam _____

Name _____ Date of birth _____

Sex _____ Age _____ Grade _____ School _____ Sport(s) _____

Medicines and Allergies: Please list all of the prescription and over-the-counter medicines and supplements (herbal and nutritional) that you are currently taking.

Do you have any allergies? ☐ Yes ☐ No If yes, please identify specific allergy below.
☐ Medicines ☐ Pollens ☐ Food ☐ Stinging Insects

Explain "Yes" answers below. Circle questions you don't know the answers to.

GENERAL QUESTIONS	Yes	No	MEDICAL QUESTIONS	Yes	No
1. Has a doctor ever denied or restricted your participation in sports for any reason?			26. Do you cough, wheeze, or have difficulty breathing during or after exercise?		
2. Do you have any ongoing medical conditions? If so, please identify below: <input type="checkbox"/> Asthma <input type="checkbox"/> Alergia <input type="checkbox"/> Diabetes <input type="checkbox"/> Infections Other: _____			27. Have you ever used an inhaler or taken asthma medicine?		
3. Have you ever spent the night in the hospital?			28. Is there anyone in your family who has asthma?		
4. Have you ever had surgery?			29. Were you born without or are you missing a kidney, an eye, a testicle (males), your spleen, or any other organ?		
HEART HEALTH QUESTIONS ABOUT YOU	Yes	No	30. Do you have groin pain or a painful bulge or hernia in the groin area?		
5. Have you ever passed out or nearly passed out DURING or AFTER exercise?			31. Have you had infectious mononucleosis (mono) within the last month?		
6. Have you ever had discomfort, pain, tightness, or pressure in your chest during exercise?			32. Do you have any rashes, pressure sores, or other skin problems?		
7. Does your heart ever race or skip beats (irregular beats) during exercise?			33. Have you had a herpes or MRSA skin infection?		
8. Has a doctor ever told you that you have any heart problems? If so, check all that apply: <input type="checkbox"/> High blood pressure <input type="checkbox"/> A heart murmur <input type="checkbox"/> High cholesterol <input type="checkbox"/> A heart infection <input type="checkbox"/> Kawasaki disease Other: _____			34. Have you ever had a head injury or concussion?		
9. Has a doctor ever ordered a test for your heart? (For example, ECG/EKG, echocardiogram)			35. Have you ever had a hit or blow to the head that caused confusion, prolonged headache, or memory problems?		
10. Do you get lightheaded or feel more short of breath than expected during exercise?			36. Do you have a history of seizure disorder?		
11. Have you ever had an unexplained seizure?			37. Do you have headaches with exercise?		
12. Do you get more tired or short of breath more quickly than your friends during exercise?			38. Have you ever had numbness, tingling, or weakness in your arms or legs after being hit or falling?		
HEART HEALTH QUESTIONS ABOUT YOUR FAMILY	Yes	No	39. Have you ever been unable to move your arms or legs after being hit or falling?		
			40. Have you ever become ill while exercising in the heat?		
			41. Do you get frequent muscle cramps when exercising?		
			42. Do you or someone in your family have sickle cell trait or disease?		
			43. Have you had any problems with your eyes or vision?		
			44. Have you had any eye injuries?		

Figure 2 Preparticipation Physical Evaluation History Form

A good example of what is being done is PrivIt[®] electronic Pre-Participation Evaluation application that is available at <http://www.e-ppe.com>.

The description present in the web page is:

“The electronic Pre-Participation Evaluation (e-PPE) is an on-line medical questionnaire that can identify symptoms of health problems that may pose a risk for an athlete participating in sport and exercise. e-PPE complies with international privacy rules including HIPAA and FERPA. The e-PPE features the ability for sport administrators, school officials and athletic trainers to track athlete rosters and ensure each athlete’s PPE has been completed.”

After completing the questionnaire, summary forms can be printed to take to a physician or athletic trainer.

The web-based application includes the items present in Table 2:

Table 2: e-PPE description

Item	Description
Consent To Participate	This form must be signed by the athlete or guardian (if under the age of consent) and physician prior to participating in any sport.
Emergency Information	This form contains all necessary information required in case of an emergency. It includes all contact information for the athlete, emergency contacts and physician. Additionally, it contains any critical medical information, such as allergies, medications and vaccinations.
e-PPE Medical History Summary	This form is a comprehensive description of the athlete's medical history as entered in the system. It relays all necessary information to a clinician to allow him/her to make an informed decision as to the athlete's health status.
Physical Examination Form	This form is a checklist to be used by the physician during a medical examination of the athlete to ensure that all necessary and relevant aspects have been evaluated.

Studies recommend a system like NCAA e-PPE as it serves as a tool in tracing and assessing both present and previous health issues of student athletes. (Joy, Paisley, Price, Rassner, & Thiese, 2004) (AAFP et al., 2010). Internet is praised as an ideal platform for the establishment of a portal/community where medical and scientific experts can share information for the purpose of improving the performance in clinical practice and advancing science related to PHE. An Internet platform can also act as a forum for ongoing education of medical, administrative and athlete participants (Ingersoll, 2009) (AAFP et al., 2010). A Web-based version of the PPE questionnaire would be a time-and cost-efficient incremental step in the evolution of the PHE, optimizing the follow-up and ongoing medical care (AAFP et al., 2010) providing an efficient mean to enforce data-collection standards across multiple input points, thus improving the accuracy of any research outcomes (Ingersoll, 2009).

To the best of our knowledge, no similar application is being used in Portugal, but our PPE, the *Exame Médico Desportivo* has the advantage of being standard nationwide.

4. System Design

At the moment and within the scenario observed in the workflow of EAMD processes, information technologies are used mainly for administrative purposes. Figures 3 and 4 illustrate main procedures that are currently performed in the Healthcare Institution and in a Sports Institution visit.

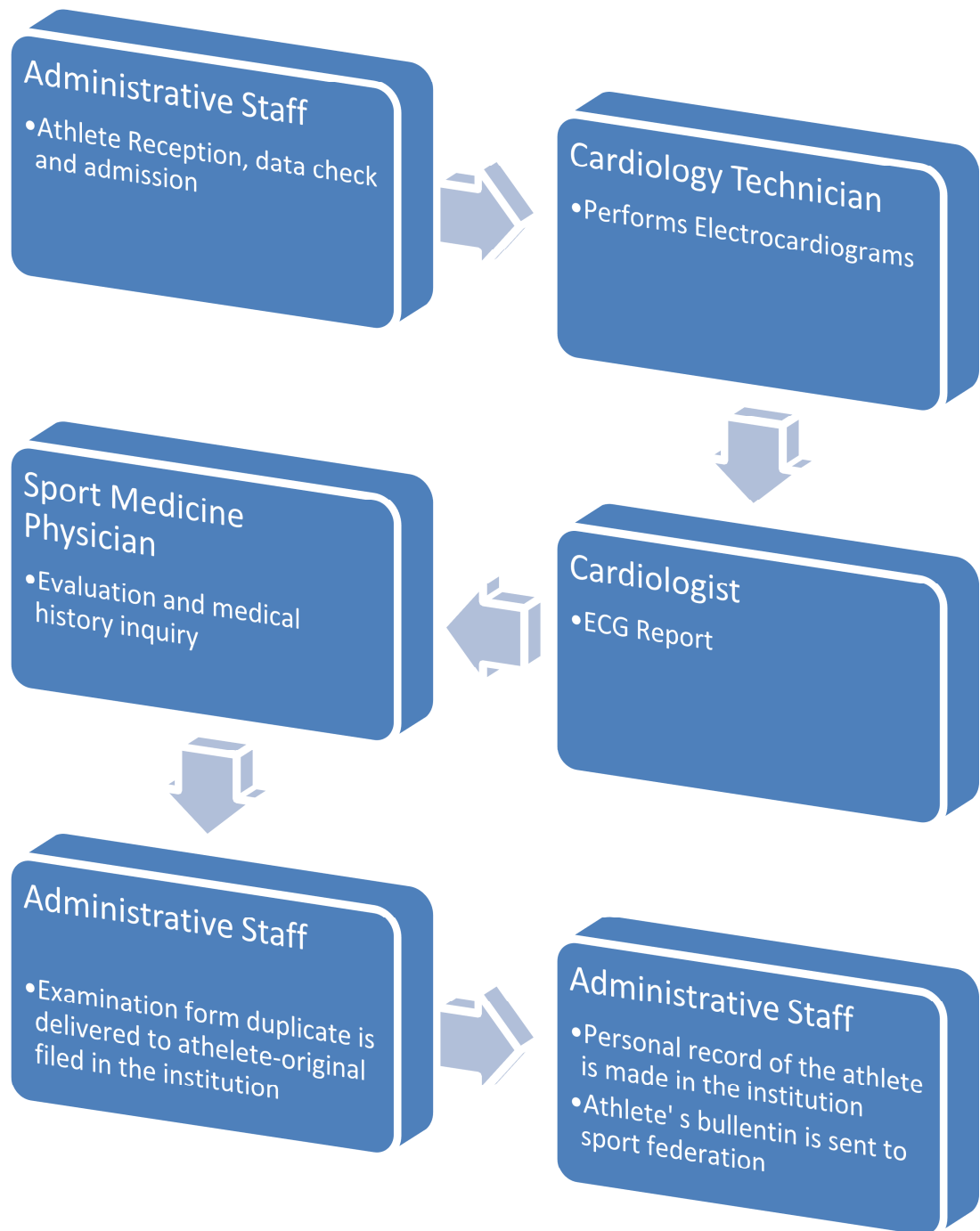
EAMD made in Healthcare Institution facilities

Figure 3 - Workflow in a Healthcare Institution

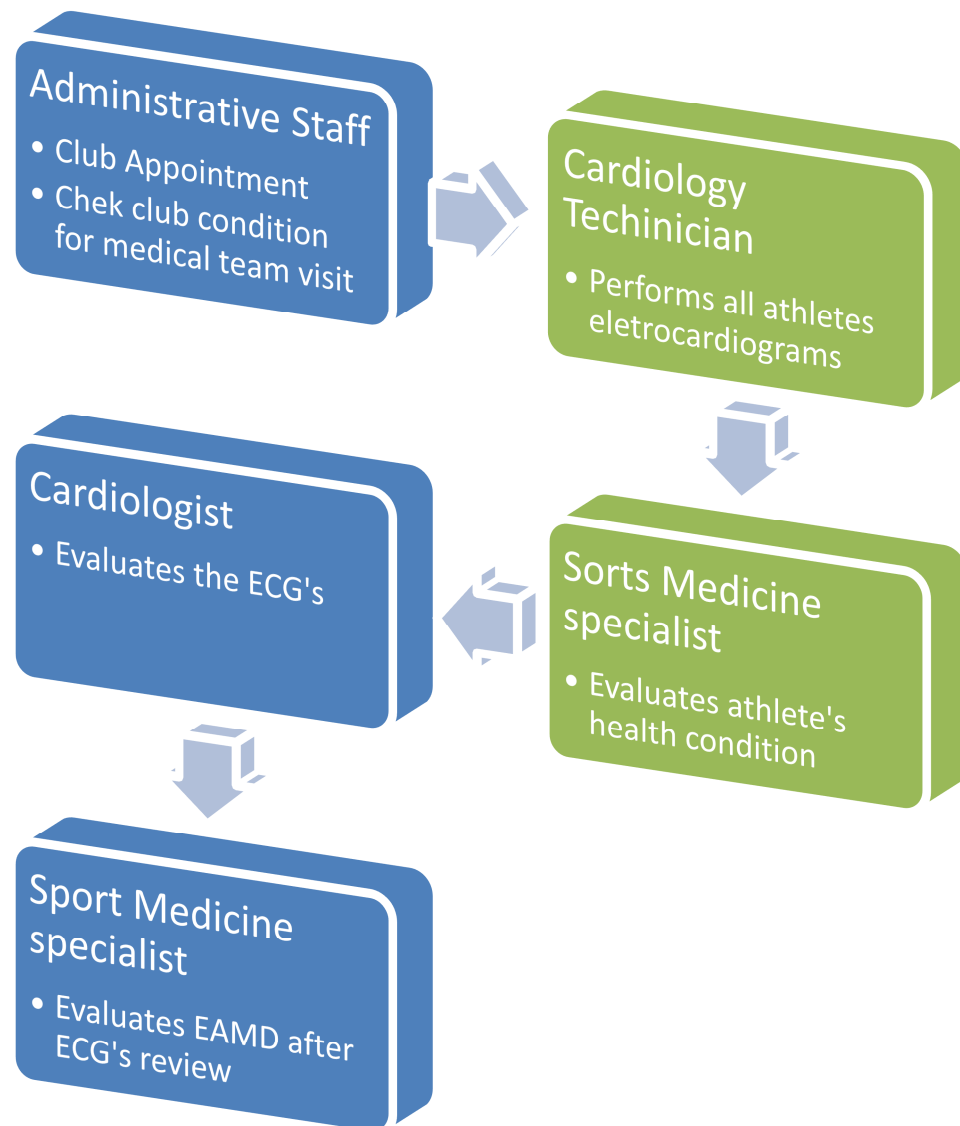
EAMD made in a Sport Institution visit with medical staff

Figure 4 - Workflow in a Sports Institution visit with medical staff

■ Healthcare Institution ■ Sports Institution

4.1 Legal, Ethical and Medical Aspects

In Portugal, access to sports practice by athletes within the sports federations depends on sufficient evidence of physical fitness of the practitioner to ensure through medical examination, that no contraindications are present. (*Lei de Bases da Actividade Física e do Desporto - Lei nº 5/2007, de 16 de Janeiro*). For a valid exam, it is necessary a completed and approved Examination form as published in Diário da República. (*Despacho nº 25 357/2006, de 28 de Novembro de 2006*).

The form consists in 13 items: Athlete personal declarations (Signed by the athlete or parent; Family, personal and sports history; Biometric, ectoscopic, ophthalmic, Otolaryngology, dental, abdominal, genital-urinary, cardiovascular and respiratory exam; Diagnostic exams such as electrocardiogram or x-ray (Ramos, 2010).

In all areas that deal with information, particularly when it involves personal sensible information, most specifically health records, questions related to information security gains particular importance.

Information security can be defined as the ability to preserve the following aspects: Confidentiality - Ensuring that information can only be accessed by someone with proper authorization; Integrity - Ensuring the accuracy and completeness of information and how it is processed; Availability - Ensuring that authorized users have access to information where this is required (ACSS, 2009).

Data should be processed only for the purposes indicated and agreed by the athlete and or his/her legal representative. A written Informed Consent should be always presented. In this study an informed consent was delivered to participants. See appendix I.

When designing a clinical application , the following laws should be observed:

Law N° 67/98 – “*Lei da Protecção de Dados Pessoais*”

It applies in the Portuguese Law, the directive 94/46/CE, of the European Parliament, relative to the protection of singular persons respecting their personal data and free circulation of that data;

Law N° 12/2005 – “*Informação Genética Pessoal e Informação de Saúde*”

It establishes the juridical regime of “Healthcare Information”;

Law N° 46/2007 – “*Acesso aos documentos administrativos e a sua reutilização*”
Applies to the Portuguese Law the directive n° 2003/98/CE of the European Parliament, relative to the reuse of information in the public sector.

4.2 Technical Components

The electronic *Exame de Aptidão Médico Desportivo* (e-EAMD) form structure must follow the *Exame Médico Desportivo* paper form, but also has additional fields like observations, available for sports medicine physician's needs. With the proper credentials and profile, a cardiologist should be able to access and interpret an ECG as seen in Figure 6, with all security aspects observed and print possibilities. The action should be audited in system logs. Figure 5 shows an actual entrance in the system logs table:

idLogActividade	329
idActividade	17
nomeUtilizador	test Cardiologist
pagina	/eamd/reservado/areaMC/consultarExame.php
endereçoIP	193.136.35.???
dataHora	24-07-2012 00:57
stampUtilizadorPaginaDataHora	08bc3b08156089bd9bd59cecfed5d628c722206f
obs	Cardiologist evaluated and signed the ECG

Figure 5 - Log entrance preview

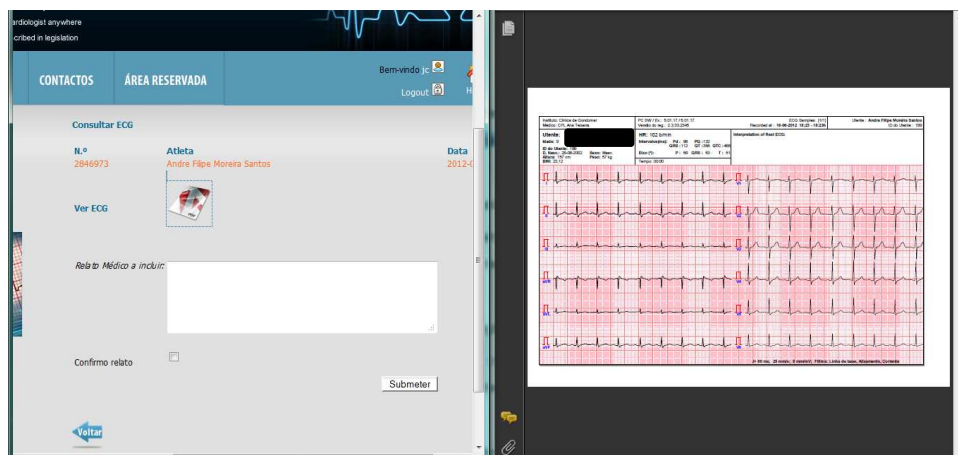


Figure 6 - ECG Interpretation action

An athlete in the system should also have access to his private exam list, as seen in Figure 7, and provide a copy to sports institution, when asked for a proof of physical fitness. Figure 8 demonstrates this feature.



Figure 7 - Athlete access to personal exams

Figure 8 - Athlete EAMD validation form

This action is also audited in system logs.

The system is web-based because it should be available anywhere. It is available at eamd.org domain. PHP programming language was chosen due to the fact that PHP is a scripting language that is especially suited for Web development and mainly HTML-embedded. Much of its syntax is borrowed from other programming languages, such as C, with a couple of unique PHP-specific added. The goal of the language is to allow web developers to write dynamically generated pages quickly (PHPGroup, 2012).

A database was designed to include the e-EAMD structure, security aspects (user logins and roles), system activities logs and documents management, etc.

The database was developed in MySQL, a relational open source database management system. MySQL has over 100 million copies of its software downloaded or distributed throughout its history and has become one of the preferred choices for Web (MySQL, 2012).

The chosen document format in the system is Portable Document Format (PDF), due to its flexibility and wide acceptance.

4.3 Use Case Diagram

The Use Case Diagram (Figure 9) represents the actors identified in the design stage of the application and their interaction. It illustrates system purpose and the ongoing system development directions and current requirements.

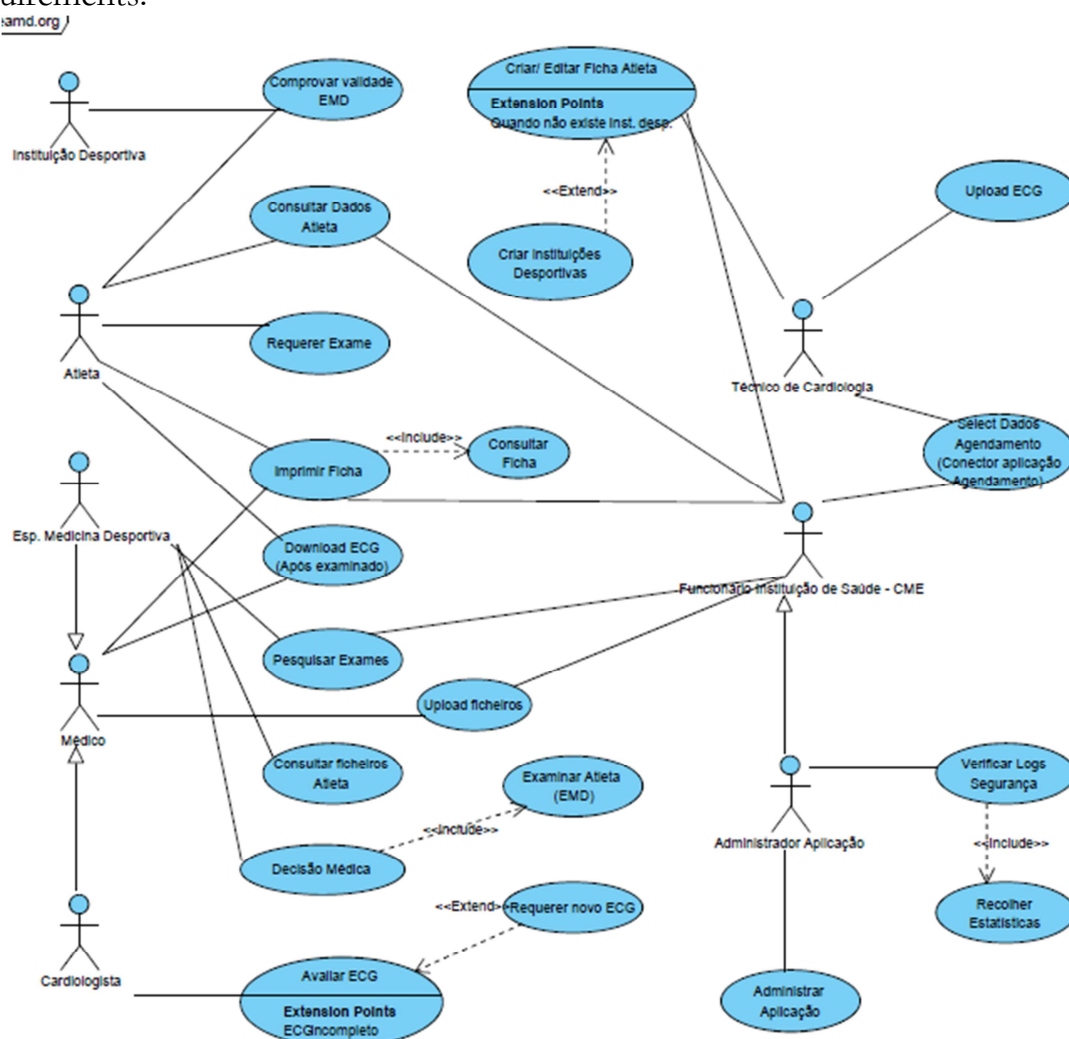


Figure 9 - Use Case Diagram

4.3.1 Database Conceptual Model

In the design stage of the project and to better understand what data is collected and its relation, the conceptual model was created. This model, presented in Figure 10, reflects the entities that must be present and their relations and actions in the system.

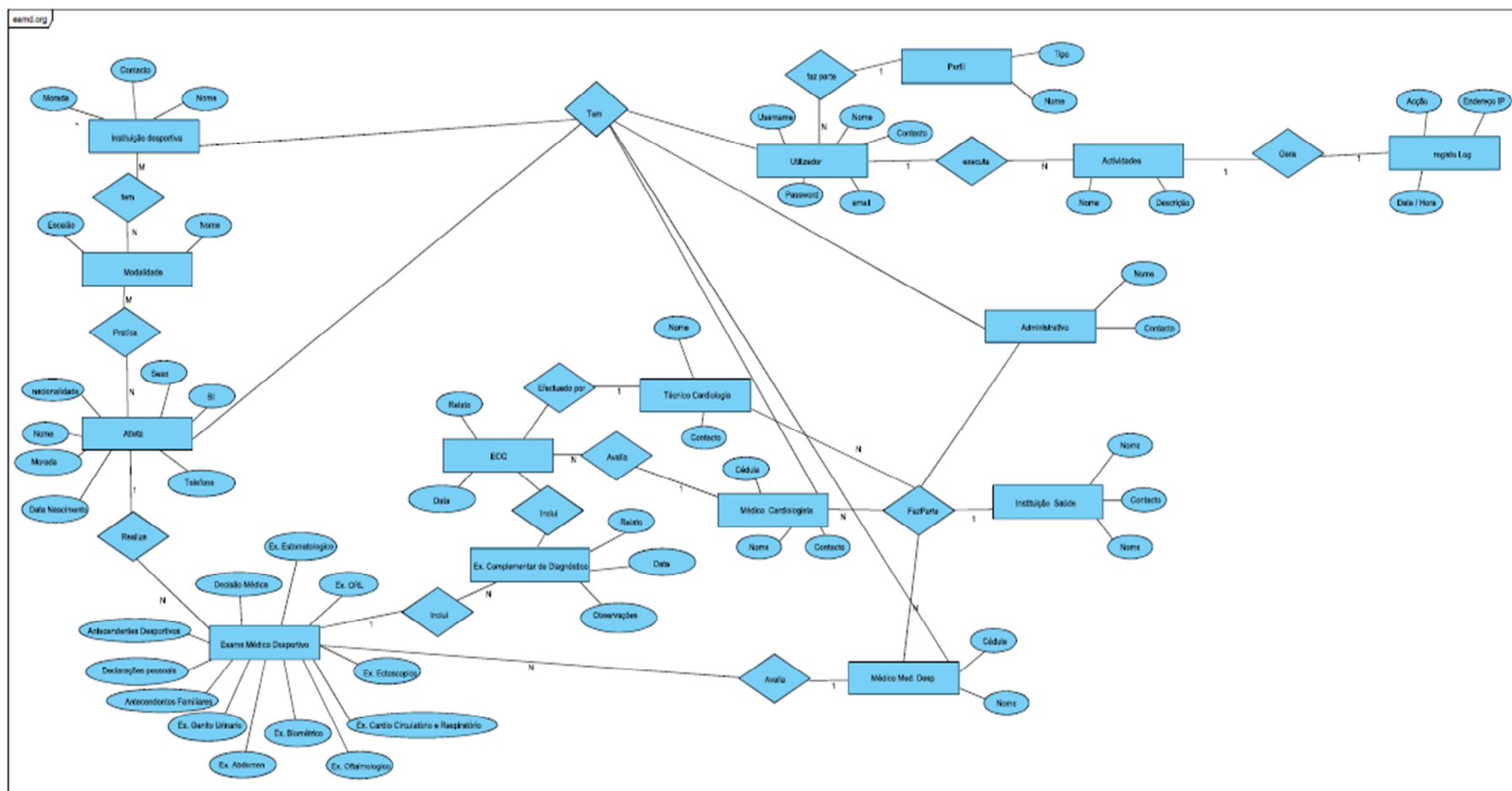


Figure 10 - Database Conceptual Model

Conceptual model showed us that, for instance, that the *Exame Médico Desportivo* entity (Figure 11) must contain all the 13 items of the form and its related fields and sub-fields.

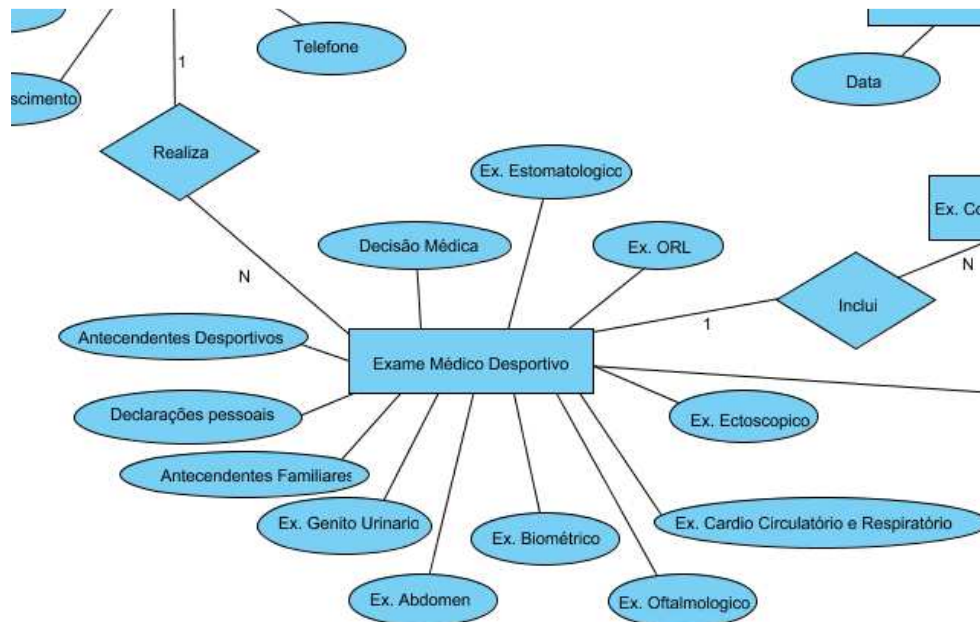


Figure 11 – Entity Exame Médico Desportivo

4.3.2 Database Schema

From the conceptual model the relational database schema was created (see Figure 12) to store all data being collected by system activities. The application, as previously described, collects a significant amount of data and it is relatively large.

To accommodate all of the items in the paper form and to relate data in database tables, fields such as the number of the exam and the number of athlete were created in several tables. This was used in all tables which are part of the exam.

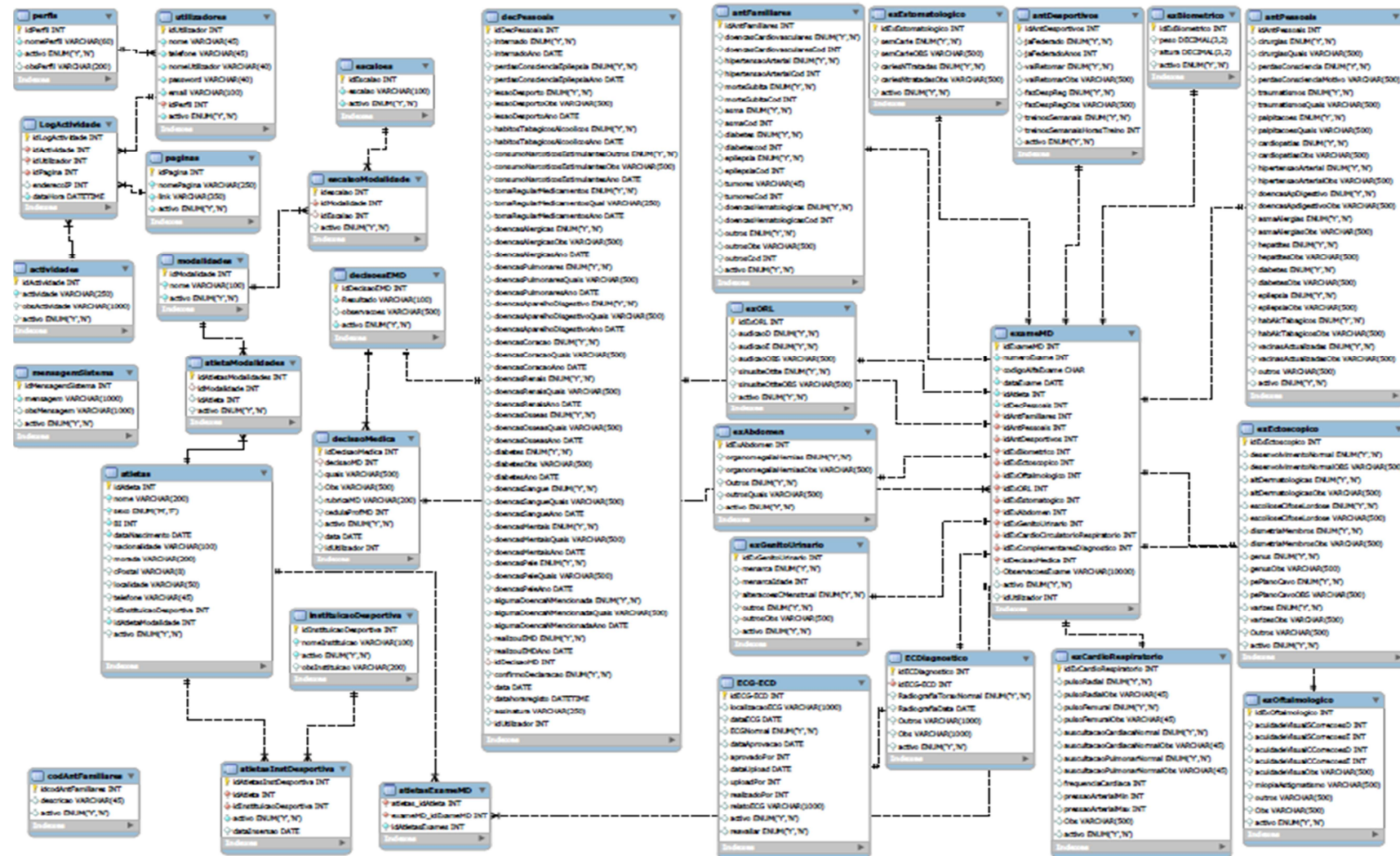
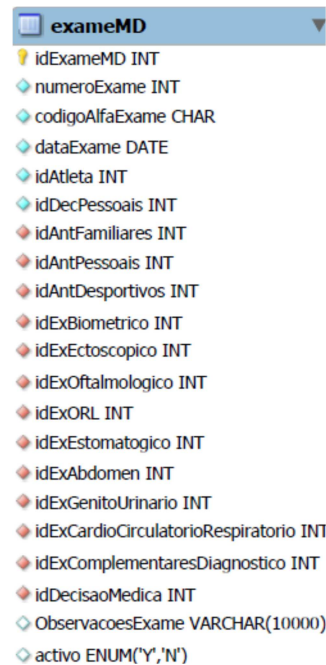


Figure 12 - Database Schema

Maintaining prior example, the *Exame Médico Desportivo* table has the numeroExame and idAtleta relational fields as displayed in figure 13.



exameMD	
idExameMD	INT
numeroExame	INT
codigoAlfaExame	CHAR
dataExame	DATE
idAtleta	INT
idDecPessoais	INT
idAntFamiliares	INT
idAntPessoais	INT
idAntDesportivos	INT
idExBiometrico	INT
idExEctoscopico	INT
idExOftalmologico	INT
idExORL	INT
idExEstomatogico	INT
idExAbdomen	INT
idExGenitoUrinario	INT
idExCardioCirculatorioRespiratorio	INT
idExComplementaresDiagnostics	INT
idDecisaoMedica	INT
ObservacoesExame	VARCHAR(10000)
activo	ENUM('Y','N')

Figure 13 – Database table “Exame Médico Desportivo”

4.3.3 Security Concerns

Communications security is provided by Secure Sockets Layer (SSL) Web Server Certificate technology to secure confidential information exchanged online. An SSL certificate is a digital certificate that authenticates the identity of a website and encrypts information sent to the server using SSL technology. Encryption is the process of scrambling data into an undecipherable format that can only be returned to a readable format with the proper decryption key.

Directory security is assured by preventing browsing and direct access through .htaccess (hypertext access) Apache Webserver technique, URL manipulation and extension handling is implemented to conceal real programming language, exposing only html extension through the same mechanism.

Cryptographic hash functions are also used to certify every document printing, creation and storage.

System logs stores a Secure Hash Algorithm code (SHA1), constructed with User name + Page name + Date Time strings. The same code is included in any document footer as Figure 14 shows.

9. EXAME ESTOMATOLÓGICO	SIM	NAO
1. Sem Cárie/Cárie Tratada/Faltas/Prótese	X	
2. Cáries não tratadas		X
Observações:		

Código: 6cf7296176fdd88bd99291ddea5711bef6522409 - eamd.org - 3 / 4

Figure 14 –Example of an EAMD document footer

For system access, several levels of security were designed: Sports Medicine specialist, Cardiologist, Cardiology Technicians, Athletes, Sports Institutions, Healthcare Institution administrative staff.

Table 3 summarizes security mechanisms principles and needed measures (ACSS, 2009).

Table 3: Security mechanisms observed

Principle	Prevention	Detection / Correction
Confidentiality	Access Control Authentication Encryption	Auditing and monitoring
Integrity	Support for data entry Standards and coding Methods Internal consistency	Auditing and monitoring
Availability	Redundancy of equipment ASR Systems	Auditing and monitoring Backups Redundancy of equipment

Confidentiality in the application is assured by mechanisms already described. Availability is of responsibility of the application hosting plan subscribed and is configured in the hosting account Control Panel of the Web Server. Integrity is an ongoing process, but all the user inputs (especially sports medicine specialist) are aided by visual alerts and confirmations as exemplified in the next figure.

Exame Médico Desportivo

Exame N.º 4344

Data [Error]

Nome ddsfdsf

BI [Empty]

Data / Nascimento 2012-06-18

Nacionalidade PORTUGAL

Morada [Empty]

Código postal [Empty]

Localidade [Empty]

Telefone 12313123

Clube XPTO

Modalidade Voleibol

Escala Iniciados

Nome Médico Dr. José Ramos

➔ Seguinte

Figure 15 - Data input visual aid

4.4 Limitations

At this stage of system design, the following limitations are obvious in the application:

- For a valid exam, it is necessary a concluded examination form as published in *Diário da República*, leading to duplicate entries and inflated time for each exam (paper and electronic format) that only can be justified by system implementation gains in every other aspects;
- Sports medicine physicians must fill and sign the paper form header;
- Clinical history validation and confirmation relies on the fact that the athlete returns to the same healthcare institution or others that may use the system.

5. System Implementation

As intended in the design stage, the eamd.org system has most of the functions of a management information system, including the input of data, edition, deletion and document upload. In accordance with the principles of design in online information systems (Simin & Jinhai, 2009) have the following abilities:

- Can be used when an Internet connection is available (e.g. Healthcare institutions facilities, at home, etc...);
- The system is simple, because the starting point of system development is to provide convenience so that people who do not understand the computer can easily use.
- It's easy to expand the database according to the change of environment and conditions to meet higher requirements.

Being eamd.org an Internet based project, available at <https://www.eamd.org>, teams and sports federations may also benefit from having a way to easily verify EAMD validity.

Billing / appointment system is not connected to eamd.org by now since it involves third party software interface data model that was not available.

The eamd.org Web Application, as a telehealth featured application intends to reduce distances between system actors allowing online information exchange (Brennan & Starren, 2006). The remote ECG interpretation in this prototype is made by a cardiologist that reviews the uploaded ECG PDF document generated by ECG machine software. Store-and-forward of the ECG generated file is the preferred solution. Main workflow in the application is as seen in figure 16.

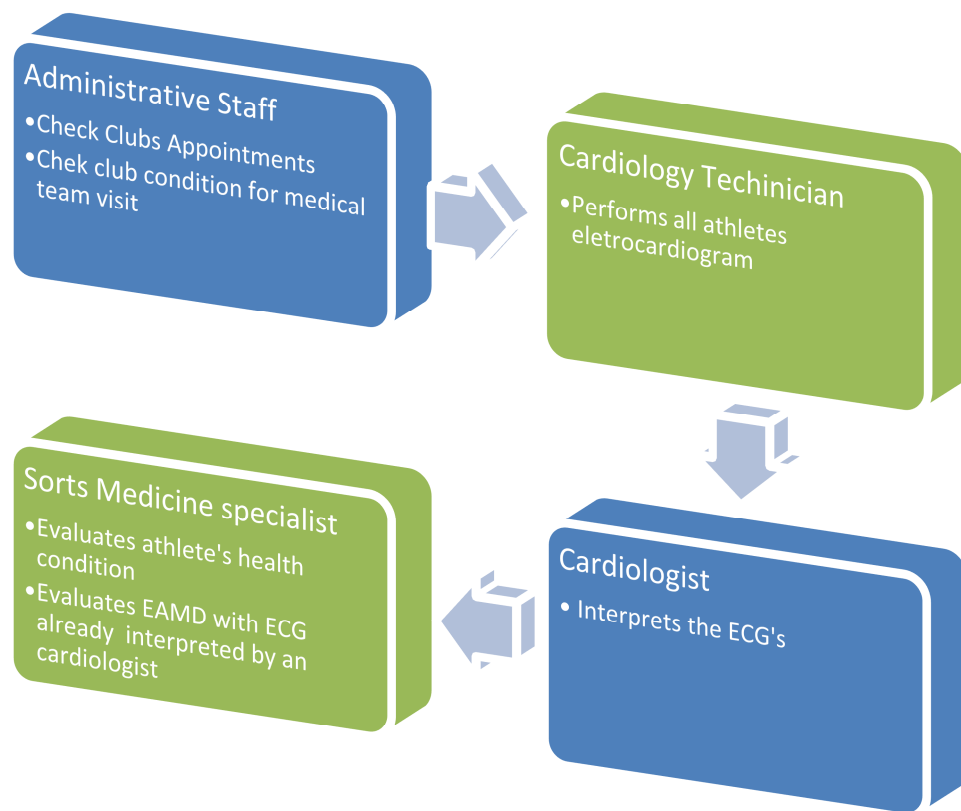


Figura 16 Web Application Workflow

■ Healthcare Institution Facilities ■ Sports Institution Facilities

5.1 Layout

System simplicity is important since a variety of users, with different computer skills will use it. A straight forward use of the application is a concern and the application implements mechanisms to aid the user in data input for the reason that a system quality depends on accurate data (Simin & Jinhai, 2009).



Figure 17- Index Page of eamd.org

5.2 Public Areas

At the moment, eamd.org public area only allows visitors to require for information and consult news relating ongoing developments.

5.3 Restricted Areas

In restricted areas, having present the security roles mentioned, after login (Figure 18), it's possible to complete the operations mentioned in the Use Case Diagram, being some of them, relevant for this study, explained below.



Figure 18- Login page of eamd.org

5.3.1 Cardiology Technician Area

Cardiology technician (CT) performs the ECG cardiac test, with the Labtech® EC software in a laptop connected to the portable Labtech® ECG EC-12R machine (Figure 19). The EC-12R, is a small and lightweight product connected wirelessly to a PC. It generates a regular A4 print size document. The software includes a user-friendly archiving and export system.



Figure 19 - Labtech® ECG EC-12R

Following the ECG, the CT creates a PDF document (see Figure 20) of the exam and uploads it to the system as exemplified in Figure 21.

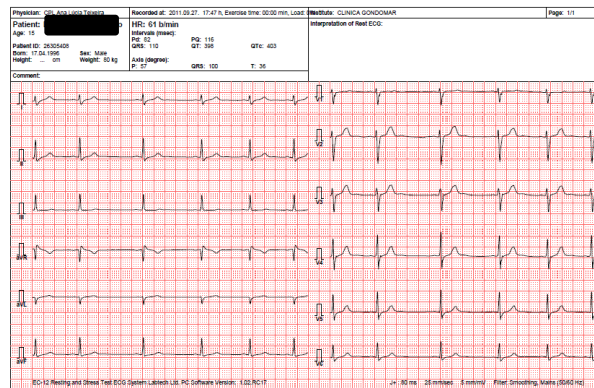


Figure 20- PDF document of an ECG



Figure 21- Cardiology technician upload page

5.3.2 Cardiologists Area

After the upload of an ECG by a CT, a cardiologist accesses the uploaded document and interprets it. See Figure 6.

Interpretation is made by accessing the platform and reviewing a list of new ECGs in the system. Cardiologist opens the ECG PDF (zooming and printing is available through installed PDF reader software) and writes the interpretation in a page textbox. After confirmation, along with the interpretation a digitalized signature is inserted in the PDF document. See Figure 22.

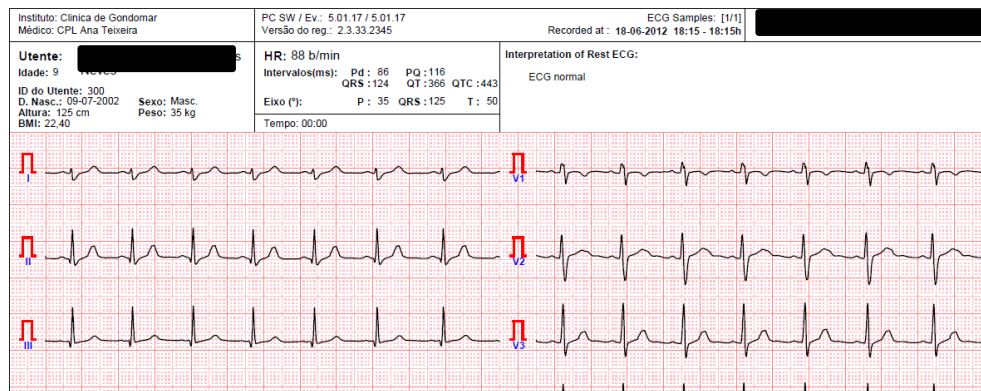


Figure 22 – Interpreted and signed ECG (digitalized signature)

5.3.3 Sports Medicine Specialists Area

Sports medicine specialist collects and reviews exams data while performing the web-based version of the EAMD paper questionnaire as in Figure 23. He verifies athlete's ECG in the process (Figure 24). This process is made by opening the web application and after sign in, accessing a list of ongoing exams. This list is populated in the electrocardiogram exam made by the CT.

2. Antecedentes Familiares

Sim / Não	Código Familiar
<input checked="" type="checkbox"/> Sim	1 - Pais
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...
<input checked="" type="checkbox"/> Sim	P.F. escolha...

Observações

EXAME MÉDICO DESPORTIVO

Figure 23- Sports Medicine Specialist e-EAMD questionnaire

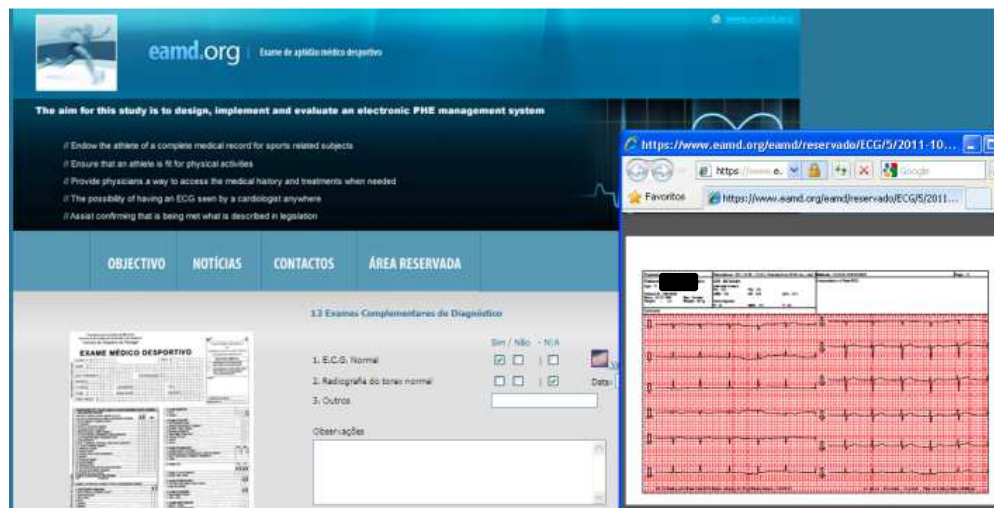


Figure 24- Sports Medicine Specialist ECG visualization

5.3.4 Athlete's Area

An athlete in the system may view the results from previously performed EAMD and its validity (See figures 7 and 8). Since the athlete owns EAMD and ECG exams, he or she can also print it (Figure 25) when completed and signed by sports medicine specialist.

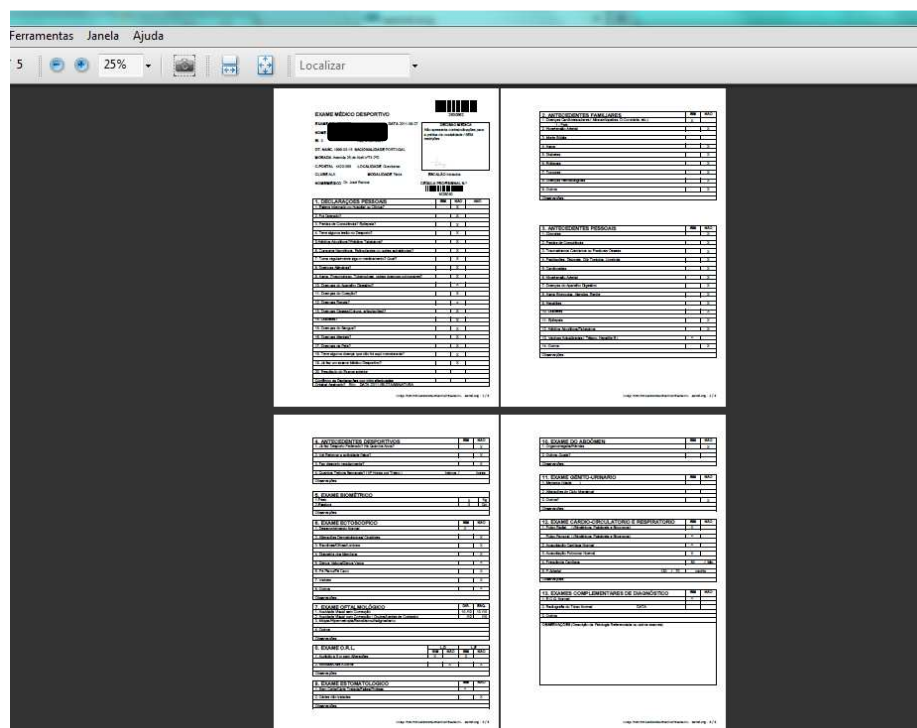


Figure 25 – Athlete EMD visualization

6. System Evaluation

6.1. Evaluation Methodology

After explaining the application prototype to the healthcare institution system actors, data was collected from 3 sports institutions with a total of 84 athletes in club visits. Exams were performed between 18.06.2007 and 05.07.2012.

Four interviews were made for a qualitative overview of the system deployment impact into the health care system actors' workflow. A cardiology technician (ID 1), a cardiologist (ID 2), a specialized sports medicine physician (ID 3) and an administrative staff member (ID 4) were then interviewed. The purpose of this approach was to collect experiences and reactions of these important actors. These interviews allowed them to speak about their experience, knowledge and views of the system. Interviews took place in Clínica de Gondomar and were guided by the following topics:

- Views on each actor profile of the need of a system like eamd.org prototype;
- Outlooks on the implementation and forced changes in actual workflow practices;
- Perspectives on the positive and negative effects related to the implementation of the system;
- Perspectives of changes in the system aiming improvements in system user's interactions.

Time taken to perform paper and electronic versions of the exam were also inquired and database results were compared with EAMD paper format. Data from personal declarations, family and personal history were examined in the search of relevant statistical information's.

Prior to the interviews, the System Usability Scale (SUS) rating questionnaire was provided. See appendix II.

SUS was developed by John Brooke at Digital Equipment Corporation in the UK in 1986 and is composed of 10 statements scored on a 5-point scale of strength of agreement. Subjective rating scales are widely used (Bangor, Kortum, & Miller, 2008) and allow a quick and easy evaluate the usability of a given product or service (Annett, 2002).

Objectives of these approaches were:

- effectiveness (the ability of users to complete tasks using the system, and the quality of the output of those tasks)
- efficiency (the level of resource consumed in performing tasks)
- Satisfaction (users' subjective reactions using the system).

6.2. Evaluation Results

Interviews results are resumed in the following table:

Table 4 – Interview results

Actor	Topic discussed	Main perspective
ID 1	Views on each actor profile need in a system like eamd.org prototype	Computerize the whole process is necessary, because currently is of difficult access for both athletes and health care professionals
	Outlooks on the implementation and forced changes in actual workflow practices	The most significant change is the export and upload of the ECG that consumes a little more time.
	Perspectives on the positive and negative effects related to the implementation of the system	Positive - the whole process is computerized Negative - It takes more time
	Perspectives of changes to the system for improvement of system user's interactions.	It must be an established form of communication between cardiology technician and sports medicine physician allowing passing information on a ECG especially outside of the Clinic.
ID 2	Views on each actor profile need in a system like eamd.org prototype	Keeps athletes ECG history and consultation easier.
	Outlooks on the implementation and forced changes in actual workflow practices	Not much, the format will change but the ECG patterns are still easily verified and interpreted.
	Perspectives on the positive and negative effects related to the implementation of the system	As negative effect the fault of the system is when no Internet connection is available.
	Perspectives of changes to the system for improvement of system user's interactions.	Email should be sent when an ECG is uploaded especially the ones that are urgent.

Actor	Topic discussed	Main perspective
ID 3	Views on each actor profile need in a system like eamd.org prototype	The need exists because it is a good solution.
	Outlooks on the implementation and forced changes in actual workflow practices	Implies the need for a computer and Internet connection.
	Perspectives on the positive and negative effects related to the implementation of the system	Positive - Possibility of storage and easy reference. Easy access to sports federations, athletes and physicians. Statistical analysis of exams results. Negative - Time of each exam is magnified.
	Perspectives of changes to the system for improvement of system user's interactions.	There must be way to select multiple items and some points have to be optional.
ID 4	Views on each actor profile need in a system like eamd.org prototype	Extremely important especially for the optimization of the work.
	Outlooks on the implementation and forced changes in actual workflow practices	Access to the program in other locations as in clubs for easily schedule exams.
	Perspectives on the positive and negative effects related to the implementation of the system	Positive Aspects - online interaction with clubs and athletes ECG archive in digital format rather than printing. Negative aspects - it's still needed to archive exams paper form.
	Perspectives of changes to the system for improvement of system user's interactions.	I do not have sufficient knowledge of the application and cannot have an opinion about possible improvements to my department.

The time taken to perform the EAMD paper version as an average time of 13 minute but increases to 22 minutes when sports medicine specialist perform both.

Comparing the paper version to the electronic version of the 84 athletes exams, main findings were:

- data corresponding to biometric examination is never present in both formats. (A system error in the application page textboxes does not force its completion, and physician does not write it because of the fact that this measurements are made in the ECG exam)
- genital-urinary exam part is never written in the paper form but is present in the database (the application forces responses to continue)
- Sports history is present in all electronic version of the PHE and never in the paper form. (the application forces responses to continue)
- Observation fields were mainly used in personal and family history declarations in equal manner in both formats.

Athletes in the system had a mean age of 14,9 years and a median age of 13,5 years old.

Personal declarations and history items present in the e-EAMD database tables was exported. The 3 questions with the highest number of affirmative answers from mentioned items are summarized in Table 5.

Table 5 – Personal and History Database Table results

Form item	Findings
Athletes personal declarations	<ul style="list-style-type: none"> - 63% answered that this was not the first EAMD made; - 23,8% have been admitted at least once into an hospital; - 13% had a sports related injury;
Family history	Pathologies reported: <ul style="list-style-type: none"> - Diabetes - 19%; - Cardiovascular disorders - 10,7%; - Asthma history in the family - 9,5%.
Personal history	<ul style="list-style-type: none"> - 22,6% underwent a surgical procedure; - 10,7% have reported that previously had asthma or some form of allergy; - 3,5% had a bone fracture or an head injury.

The SUS questionnaire resulted in mean score of 84 (n=4) as seen in Table 6.

Table 6 - SUS Score Summary

Question	ID 1	ID 2	ID 3	ID 4
1	4	4	4	3
2	4	4	3	3
3	4	4	3	4
4	1	1	4	3
5	3	3	4	3
6	4	3	4	3
7	4	4	4	4
8	4	4	4	4
9	3	3	3	3
10	0	4	4	3
SUS Score	77,5	85	92,5	82,5

6.3. Evaluation Discussion

Users can complete their tasks using the eamd.org system, and with corrections e-EAMD data may be more accurate. Sports medicine physician needs to have fields open of validation in order to continue efficiently because some points may not need an answer (e.g. number of weekly trainings).

Data accuracy in this first test is invalid in some exams due to previous mentioned problem.

Duplicate data entry imposed by legislation is one big drawback for the system but in time, the amount of time should decrease as healthcare professionals show strong interest in its use.

The percentage of athletes declaring that have already done an EAMD seems to justify the history validation needs expressed by sports medicine specialist, but for medical history confirmation purposes, the application should be used at another level (e.g. national).

SUS questionnaire resulted in mean score of 84 reflecting user satisfaction using the system, but with a number so small of SUS delivered and seen only from the perspective of current users of health systems actors may appear irrelevant. Ideally this questionnaire should already be presented to all system actors for better analysis.

7. Conclusion

7.1. Main Conclusions

The implementation of this e-EAMD platform, relating to sports medicine exams, complies with the published EAMD form structure. EAMD structure follows current standard, is well designed and widely approved so an e-EAMD system development should always follow that configuration. Part of the exam is supplementary studies, such as ECG and must be present in the system design.

This prototype had a positive feedback from the Healthcare providers involved in the project and allowed them to accomplish their tasks. If the platform is maintained further in time could be a growing repository of data with interesting statistical analysis

Legal issues cannot be ignored, they have to progress to allow electronic data treatment for the EAMD, consenting further research.

A documented positive feature to all actors is the possibility of assuring physical fitness at any time.

This prototype follows current standards and may be one more positive example of how information technologies may optimize the doctor-patient relationship.

7.2. Main Recommendations

After a larger evaluation, sports medicine physicians should perform only one version of the exam avoiding the increased time (e.g. only electronic version and EAMD paper form header signed).

The progression of this type of solution should be embraced at a higher level, such as *Instituto do Desporto de Portugal*, with several others healthcare

institutions and physicians registered to share athlete's data and reaching more people.

7.3. Future Work

The application prototype must be corrected, allowing clubs and athletes access, permitting the insertion of personal declarations before scheduled exams. For instance, an athlete could have prior access to the web application, in a reserved environment completing personal statements (actual system let the athlete print and sign, but the healthcare institution actors still fills in the athlete's data in the application).

Security aspects should be improved to include Digital Signatures, from login to legal validation purposes. Portuguese Citizen Card is a possible solution as a present day reality.

The development of this prototype intends to be one more step in collecting facts for future work.

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Appendix

Appendix I – Informed Consent



TERMO DE CONSENTIMENTO INFORMADO

Os participantes neste estudo de implementação e avaliação de um sistema electrónico do Exame Médico Desportivo, irão ser sujeitos a alterações na forma de como as suas informações são tratadas, tais como a) registo de dados pessoais em formato digital com possibilidade de consulta e impressão por parte do Atleta; b) ECG e outros exames (quando realizados) em formato digital disponíveis para o Atleta e para os médicos autenticados no sistema; c) Possibilidade de ser comprovada a validade de um exame *online* pelos médicos, pelo atleta e Instituições Desportivas quando autenticados no sistema.

Os dados recolhidos para a pesquisa servirão apenas para fins de avaliação e melhoria do sistema, sendo a identidade dos participantes preservada em todas as publicações que virão a ser realizadas com esses dados. Toda a informação será transmitida em meio seguro *online*.

Esperamos com este estudo dar um contributo para a melhoria da qualidade de serviço e de um maior conhecimento sobre os efeitos da implementação de um sistema com estas características sobre arquivos em papel.

Eu, _____, nascido(a) a ____/____/____, residente em _____ na freguesia de _____, concelho de _____, após ter sido completamente informado(a) sobre o objectivo, procedimentos e, garantida a confidencialidade dos dados do estudo, voluntariamente concordo em colaborar no trabalho de dissertação de Mestrado em Informática Médica, do aluno Emanuel dos Anjos Santos Silva, orientado pelo Professor Doutor Pedro Pereira Rodrigues e co-orientado pelo médico especialista em medicina desportiva, Dr. José Joaquim Ramos.

Gondomar ____ de _____ de _____

Assinatura do participante



FACULDADE DE MEDICINA DA UNIVERSIDADE DO PORTO
FACULDADE DE CIÊNCIAS DA UNIVERSIDADE DO PORTO
2º Ciclo de Estudos em Informática Médica



Appendix II – System Usability Scale

Participant ID: _____

Site: _____

Date: ____/____/____

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the website *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this website frequently.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	I found this website unnecessarily complex.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	I thought this website was easy to use.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	I think that I would need assistance to be able to use this website.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	I found the various functions in this website were well integrated.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	I thought there was too much inconsistency in this website.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	I would imagine that most people would learn to use this website very quickly.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	I found this website very cumbersome/awkward to use.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	I felt very confident using this website.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.	I needed to learn a lot of things before I could get going with this website.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

